UPFLOW FILTRATION FSM SYSTEM IN ROHINGYA CAMPS

Operations & Maintenance (O&M) Manual

August 2020

BIG CHANGE
starts small

RECORD OF CHANGES

Table 1: Record of Changes

Version Number	Date	Author/Owner	Description of Change
1..0	July, 2020	Practical Action and UNICEF	First O & M manual of FSM.

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1. INTRODUCTION

Population of Ukhiya and Teknaf Upazila of Cox's Bazar has augmented to more than 1.5 million people due to the influx of the Forcibly Displaced Myanmar National's (FDMN's), commonly known as Rohingya, since August, 2017. [1]These Rohingyas, living in Cox's Bazar in makeshift huts are considered as one of the most vulnerable groups living in the south-eastern corner of Bangladesh, adjacent to the border with Myanmar.The unplanned nature of the Rohingya refugee camps havingvery high population densities in challenging environmental conditions has resulted in a crisis situation, especially with its acute water, sanitation and hygiene (WASH) needs.

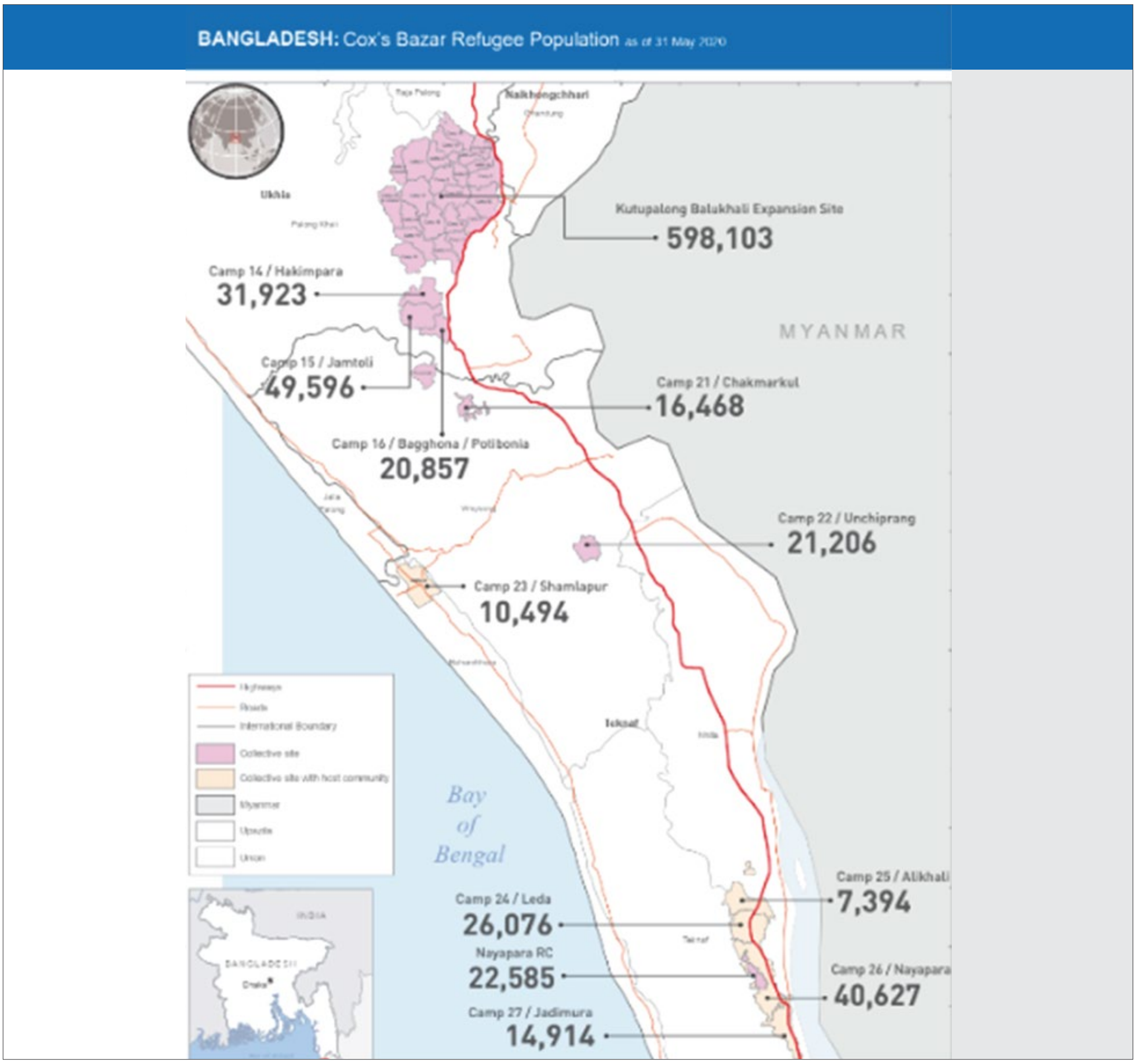

Figure 1: Cox's Bazar Refugee Camp Population

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1 Creation date: 25 January 2018 | Source: ISCG, RRRC, Site Planning and Site Management Sector. The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

According to UNDP, a total of 11,000 m3 of waste is sitting in that area that does not have a functioning waste management system, posing new health and environmental hazards. This dense population generates almost 10,000 tons of waste per month which is augmenting the adverse impact on health of the inhabitants and environment. [2]A large portion of this poorly managed waste is the untreated faecal waste. Faecal sludge (FS) management facilities are inadequate and in most cases, FSis being disposed in an open environment without any treatment.Therefore, one of the biggest challenges in the camps in Cox's Bazar is the management of huge volume of FS generated in that area.

The main sanitation facilities used by Rohingya refugees are communal latrines-blocks of multiple latrines available to all users, shared household latrines used exclusively by a small group of surrounding households, and single-household latrines. There are pit/septic tanks used as containment with these latrines. Access to pit/septic tank is challenging as there are only a few roads through the camps, hence most of the equipment as well as emptied FS are being carried by hand using drums on bamboo poles. Space in the camps are limited due to large number of people and the hilly topography of the area, which makes it difficult to install FS treatment units of adequate size.

Figure 2: Densely located households in the Rohingya camps

[2] Impacts of the Rohingya Refigee Influx on Host Communities, UNDP, November 2018

As a part of Integrated Solid Waste Management, Practical Action with the support from UNICEF introduced context specific Faecal Sludge Management (FSM) technologies to tackle the huge volume of FS generated across the Rohingya camps in Cox's Bazar. At the beginning, to tackle the huge volume of FS generated in the camps, Practical Action piloted some FSM units which were named as 1st and 2nd generation FSTP. Based on learning from piloting of these plants, the systems have been upgraded.At present, in a few Rohingya camps, 31 context specific FSM units are used where 2 types of upgraded Fecal Sludge Treatment Plants (FSTP) are in operation:

1. 3rd generation FSTP
2. 4th generation FSTP

These context specific FSM units to tackle the huge volume of FS generated across a few of the camps involve desludging from containment (pit/septic tank) using portable devices, disposal of sludge into FSTP and treatment of FS up to certain degree.

Figure 3: FSTP unit of Practical Action in a Rohingya camp

Even though a fairly stable FSM system has been established in the Rohingya camps, proper training of sanitation workers for efficient operation and maintenance of the whole system is of high importance. "Operation" means the activities that helps to ensure that an FSTP is run according to the design, whereas "Maintenance" is related to all the activities that ensure long-term operation of equipment and infrastructure. With an aim to ensure efficient operation and proper maintenance of the FSTPs installed by Practical Action in the camps, an Operation and Maintenance (O&M) Manual of the FSM units is required targeting operating institutions as well as to support other organizations who will use similar technologies in future. An Operational and Maintenance (O&M) Manual is a kind of comprehensive document which provides the necessary details about a plant as well as individual pieces of equipment to help the maintenance staff to keep everything running smoothly. In other words, O&M Manual contains information and strategies designed to guide operational stakeholders in the normal use and maintenance.

This O&M Manual for the FSTP is the basic reference for the operation and maintenance of the equipment and processes that comprise the FSTP at the Rohingya camps. Managers, operators, and maintenance personnel will use this manual to operate the FSTP. The manual contains the technical details and designs of the FSM units, a brief study on the operator/worker responsibilities and work safety protocols, and finally the operation and maintenance of the FSM units and equipment.

2. COMPONENTS OF FSM UNITS

Assessment of FS treatment requirements must start from understanding of the main sanitation options and the ways in which they influence the segments in the sanitation chain. Information on existing sanitation facilities and FS collection and transport, and the ways in which these are likely to change in the future, is required to assess the likely short- and longer-term loading and operation of the treatment plants. Changes over the planning period will include those, such as population growth, that will be largely independent of planned interventions and those achieved through interventions that aim to amend and improve services and the institutional and financial systems that support them. An example of the latter would be an increase in the volume of FS to be treated following the introduction of scheduled emptying of containments.

The FSTPs in Rohingya camps have been designed to treat raw FSby separating the solid from rawFS.This system depends on physical and biological processes to treat the sludge and liquid waste that comes with the sludge. The basic units of the plants are - dumping chamber, solid-liquid separation chambers, burial pits and constructed wetland. Considering its design steps, there are two types of treatment plants named as 3rd generation treatment units and the more updated 4th generation treatment units, where the basic mechanism for each type of treatment plant remains same with some differences in dumping and filtration processes. A schematic diagram of the service chain of the FSM units of Practical Action is shown in Figure 4. The technical details of the FSM units of the both 3rd and 4th generation system units, flow diagram of FS and brief description of the technologies being used at different steps for treatment of FS are provided in this section.

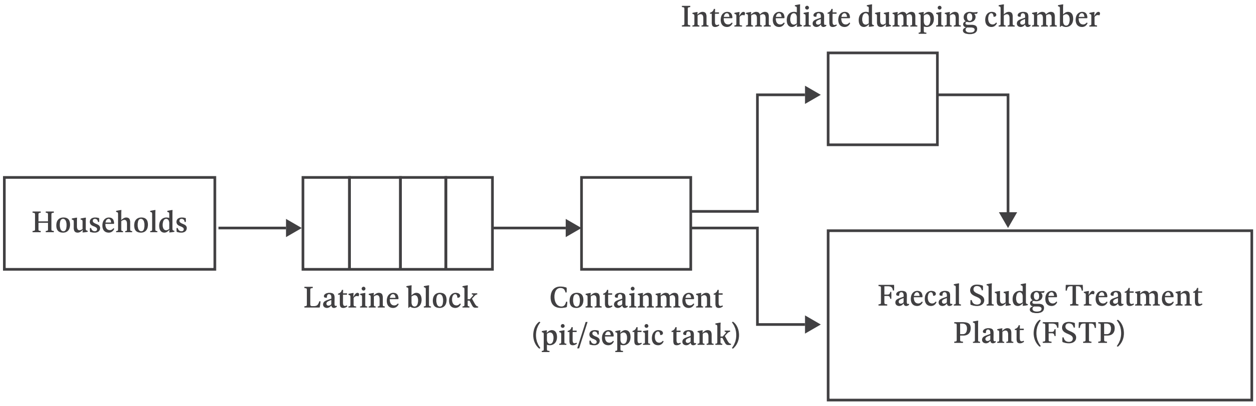

Figure 4: FSM service chain for the FSTP of Practical Action in Rohingya camps

2.1 User Interface

The FSTP sreceive FS from the latrines located near the treatment plant. Each of the Rohingya camp is divided into a number of blocks and each of these blocks has a number of latrine blocks. Each of these latrine blocks has an ID which is used for identification of the latrine and keeping records related to that latrine block. Each latrine block has 4-5 cubicles where a single cubicle is supposed to be used by approximately 4 families. Groundwater is used as the only water source in the Rohingya camps for sanitation purpose.

The FSTP receives FS from approximately 200-250 toilet cubicles (50-60 latrine blocks). Therefore, an FSM plant approximately receives faecal sludge of 1,000families, which is equivalent to 6,000 - 8,000 people approximately.

The management of the latrine blocks is done by the responsible WASH agency for the block/sub-block. The Majhi of the block looks after the maintenance of the latrine blocks and reports to the WASH agency in case of any need for repair or maintenance activities. Apart from the WASH agency and Majhi, the users can contribute in maintaining hygiene of their latrines. Therefore, the users of the latrines should receive education on how to keep the latrines hygienic. The pit emptiers often complain about presence of plastics, clothes, papers and other materials that makes desludging difficult for them. Therefore, it is important to raise awareness of the users so that they do not dispose any such objects in the toilet, which can also block the pipes that carries FS from toilet to the containments.

For ensuring good hygiene practice at the latrine blocks, few recommendations are made that should be followed:

- Proper design of the latrine to ensure that the waste is confined.
- Ensure a proper water seal to control pollution. Sealing of the passage between the squat hole and the pit to effectively block pathways for flies and other insect vectors, thereby breaking the cycle of disease transmission.
- Air vent should be properly designed and maintained.
- Supply of enough water for sanitation and hygiene.
- Privacy for users should be ensured.
- Access road to the latrine block should be safe and user friendly, especially during wet season.

2.2 Containments

Mostly two types of containment systems are in use in the visited camps, which are: single pits and septic tanks. The latrines and containments were constructed by different organizations and as a result, the design of containments may vary from one to another. Availability of land was a major factor that influenced the size and volume of the septic tanks.

Septic tanks or pits retain solids, supernatant liquid, and scum, and must be regularly desludged. Best practice design and operation of a septic tank typically involves desludging at intervals of 2–4 years but in practice desludging can take place at intervals ranging from months to decades. In the Rohingya camps, due to very high population density, the number of users for one containment is very high, which is roughly 100 to 150.

For the pits, two types of rings are used; 30" diameter ring and 48" diameter ring. The depth of the pits vary from 5 ft. to 10 ft., depending on topography and slope stability. The containments gradually get filled and needs to be desludged after a certain time. If the containments are not emptied regularly, the accumulated sludge at the bottom of the containment creates a hard layer which is difficult to desludge, and thus reduces the effective volume of the containment. Therefore, it is important that the containments are desludged properly at regular interval to not allow the settled sludge create any thick layer at the bottom of the containment.

For pits, the required frequency of desludging is high, as many of the pits need to be emptied twice in a month. For septic tanks, the desludging frequency may vary from two weeks to two months, depending on volume of the tank.

The desludging schedule is often not fixed or properly organized in the Rohingya camps. Although there is a tentative date for desludging, most of the time the desludging schedule is prepared based on demand, which means that a containment is emptied once it almost gets filled up. There are also emergency cases when a containment gets filled up without getting noticed by the sanitation workers and starts to overflow. In such cases, the sanitation workers need to act quickly to desludge the containment on emergency basis. To avoid this from happening, the record of desludging should be checked regularly to identify containments with the requirement of higher frequency of desludging.

A few recommendations for better management and performance of the containments in the Rohingya camps are:

- Venting out of foul gases generated in the pit through a properly positioned vent pipe can keep latrine odor free and encourage its continual use.
- Fly-screen at the top of the air vent to prevent passage of mosquito/fly.
- A free space of 0.5 m should be kept above the inlet pit in offset pits.
- Volume of the pit or septic tank should be sufficient to facilitate digestion of FS before emptying.

2.3 Desludging Operation

The sanitation workers, who are responsible for desludging operation, use a pump named hi-cap sucker for emptying of FS from the containments. Thehi-cap sucker (Figure5) is run by a 4-hp diesel engine and has a discharge flow rate of 50 m3/hr. It has two output heads of 2"and 3" diameter. For the emptying operation, a nozzle is attached with the sucker which creates vibration inside the containment that breaks the large solid particles into smaller bits, which makes it easier for the hi-cap sucker to easily lift the sludge.

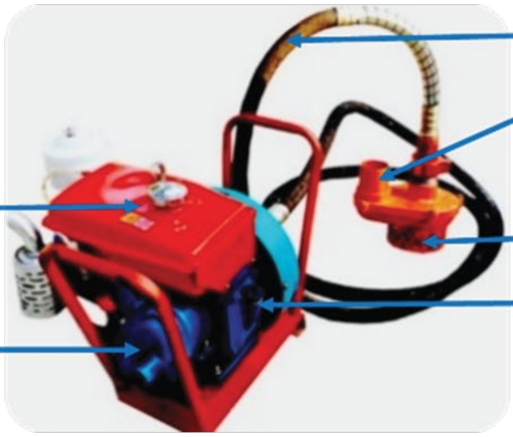

Figure 5: Hi-cap sucker used for emptying of faecal sludge in the Rohingya camps

The hi-cap sucker unit at the desludging site should be placed at allocation suitable (clean, level and no mud around). Also, the machine should be placed on the ground horizontally and the pump with modified nozzle should be inserted into the containment below the water level almost perpendicular to ground. The hi-cap sucker pumps FS into the dumping chamber/intermediate (dumping) storage chamber or directly into the solid-liquid separation chamber at the FSTP. If the location of the containment from the FSTP is more than 150 m (500 ft.), an intermediate storage chamber is needed for temporary storage of FS as the conveyance pipe can only operate within 150 m radius of the containment.

There are two different types of Intermediate storage chambers based on their capacity, 5 m3or 2 m3. Both chambers are made of plastic tank. The FS from the intermediate storage chamber is again pumped into the FSTP using the hi-cap sucker.

The sanitation workers often face challenges while operating the hi-cap sucker. As the camps are located in hilly areas, it is quite hard to find suitable places to set the engine. Also carrying the machine and pipes through the roads with steep slope is quite a difficult task for them.

Regarding operation of the hi-cap sucker, precaution should be taken while operation as sometimes the screen chamber gets damaged by sharp metals (razor, blade) which are often disposed into the containments. As a result, the fan inside the chamber often gets damaged and needs repairing. While operation of the hi-cap sucker, one sanitation worker will have to constantly monitor the FS collection pipe. If FS flows through the pipe, operation should continue. But if there is no flow, any of the two cases might be the reason:

- Case 1: Containment emptying is done and there is no FS inside the containment to desludge.
- Case 2: The screen of the pump (see figure below) got clogged or the fan inside the screen has stopped rotating due to clothes or other materials getting stuck in the fan.

In case of no flow through the pipe, the engine must be shut down immediately. Otherwise, the nozzle might get damaged.

Figure 6: Screening system at the pumping chamber of the hi-cap sucker

2.4 Treatment

The Practical Action installed treatment plants in the Rohingya camps can be divided into two types based on their design criteria- 3rd generation FSTP and 4th generation FSTP. Based on Practical Action's learning from piloting of 1st and 2nd generation FSM units, the systems have been upgraded. The main design principle for both of the FSTPs has many similarities at different steps. The main differences between the 3rd and 4th generation FSTP are the dumping process in the solid-liquid separation units and sedimentation process. The flow diagrams for a 3rd generation FSTP and a 4th generation FSTP are shown in Figure 7 and Figure 8 respectively, and discussion of the components are provided in this section.

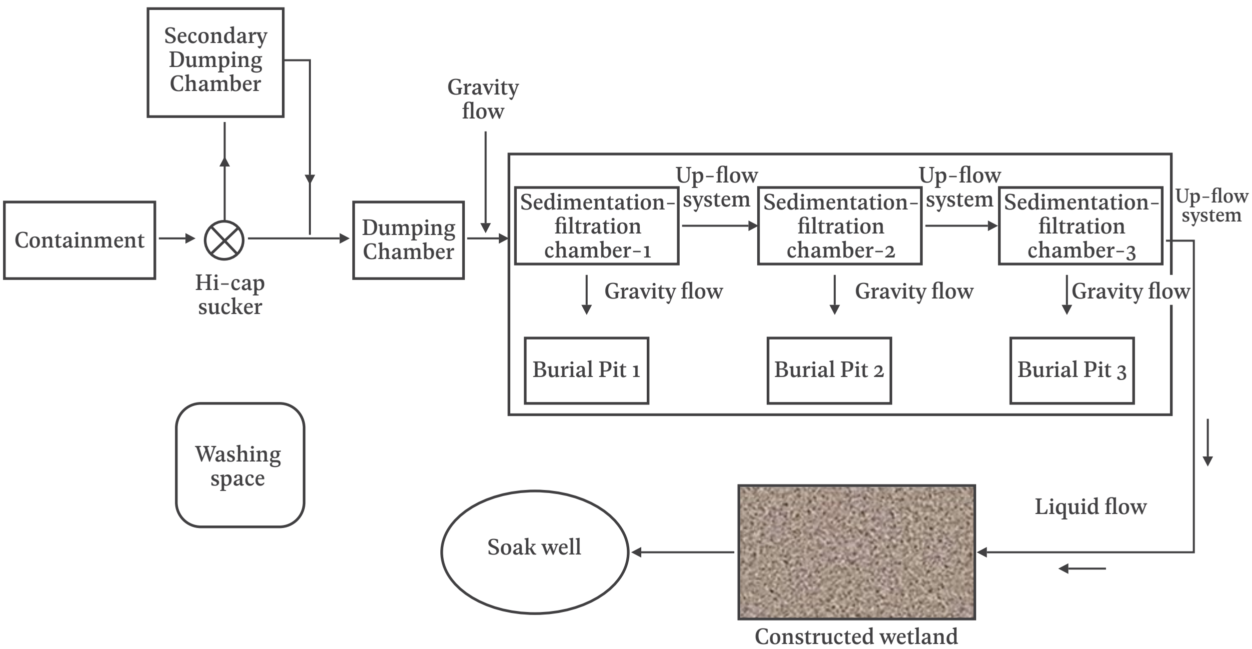

Figure 7: Flow diagram of 3rd generation FSTP of Practical Action

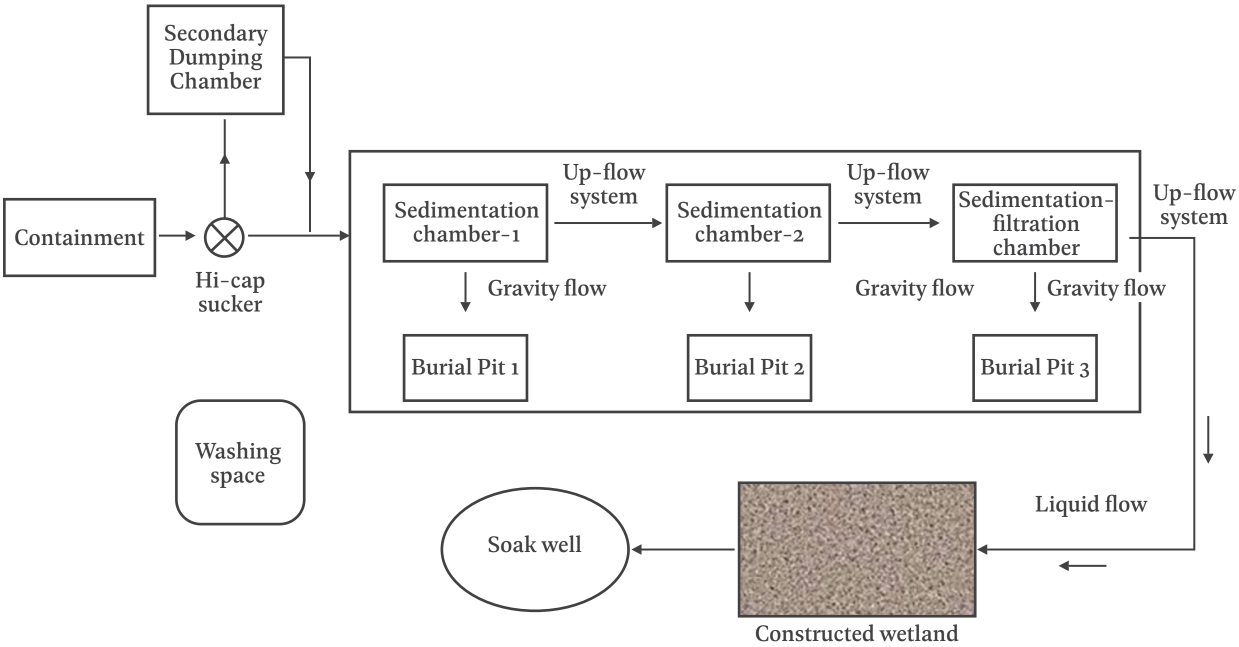

Figure 8: Flow diagram of 4th generation FSTP of Practical Action

2.4.1 4th Generation FSTP

From the flow diagram of 4th generation FSTP shown in Figure 8, it can be seen that FS is directly pumped into the solid-liquid separation chamber after desludging from containment. If the plant distance from the containment is more than 150 m, FS is carried into an intermediate storage/dumping chamber, also called as secondary dumping chamber, which is a plastic tank of either 5,000 L or 2000 L. Later FS from intermediate dumping/storage chamber is again pumped into the FSTP.

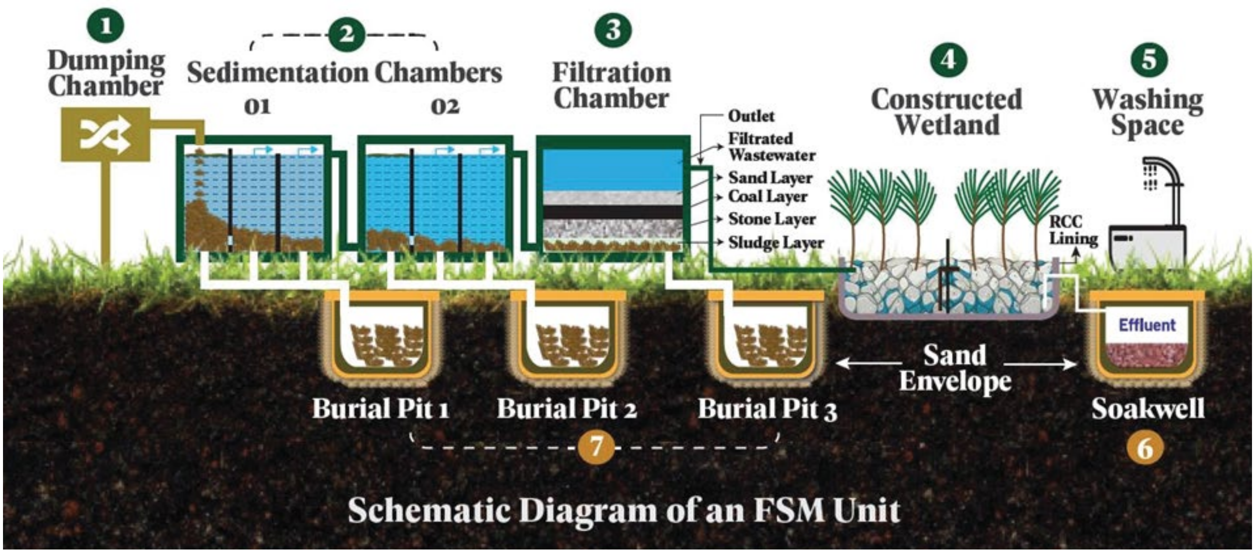

Figure 9: Schematic diagram of 4th generation FSTP

A schematic diagram of the FSM unit of 4th generation system is shown in Figure 9. The FS from containment of intermediate storage chamber is dumped into the solid-liquid separation unit of the FSTP. The first two units of the solid-liquid separation units in the 4th generation system is sedimentation chamber where FS is allowed to pass through three compartments in each chamber for sedimentation. In the third chamber, both sedimentation and filtration processes take place. All three chambers of the solid and liquid separation unit are connected to burial pits.

In the solid-liquid separation unit, the solid gets trapped at the bottom of the chamber while the liquid portion rises up by "up-flow" system. The separated solid parts are transported via an under drain pipe to the burial pits and stored there until the pits gets filled with sludge. The liquid part of the FS is transported into a constructed wetland after passing the third chamber, which is the filtration chamber, through gravity flow after coming out of the solid-liquid separation units. The liquid is treated in the constructed wetland and after passing through the wetland, it is stored in a soakage well for infiltration into soil layer.

Figure 10: Solid-liquid separation unit of the FSTP

2.4.1.1 Solid-liquid Separation Chamber

The 4th generation system has two sedimentation units followed by a sedimentation-filtration unit. Figure 11 shows the layout of the plant and connection between the three chambers of the solid-liquid separation unit. The dimensions of a chamber are 10' X 5' X 4.5'. Each chamber has a total volume of 6,300 L. Each of the sedimentation chamber has three compartments that are equal in length and separated by a plastic partition (10 mm thick).

The two sedimentation chambers are designed to facilitate settling of solids in FS. The FS from the containment or intermediate storage chamber is dumped at the bottom of the sedimentation chamber from where it follows the up-flow process to enter to the next chamber. The first compartment of first sedimentation chamber receives raw FS. There is a passage at the bottom of the first compartment which allows the raw sludge to enter into second compartment but traps the scum at the top of the compartment. After entering into the second compartment, FS rises up and is supposed to travel into the third compartment from the opening at the top of the second compartment.

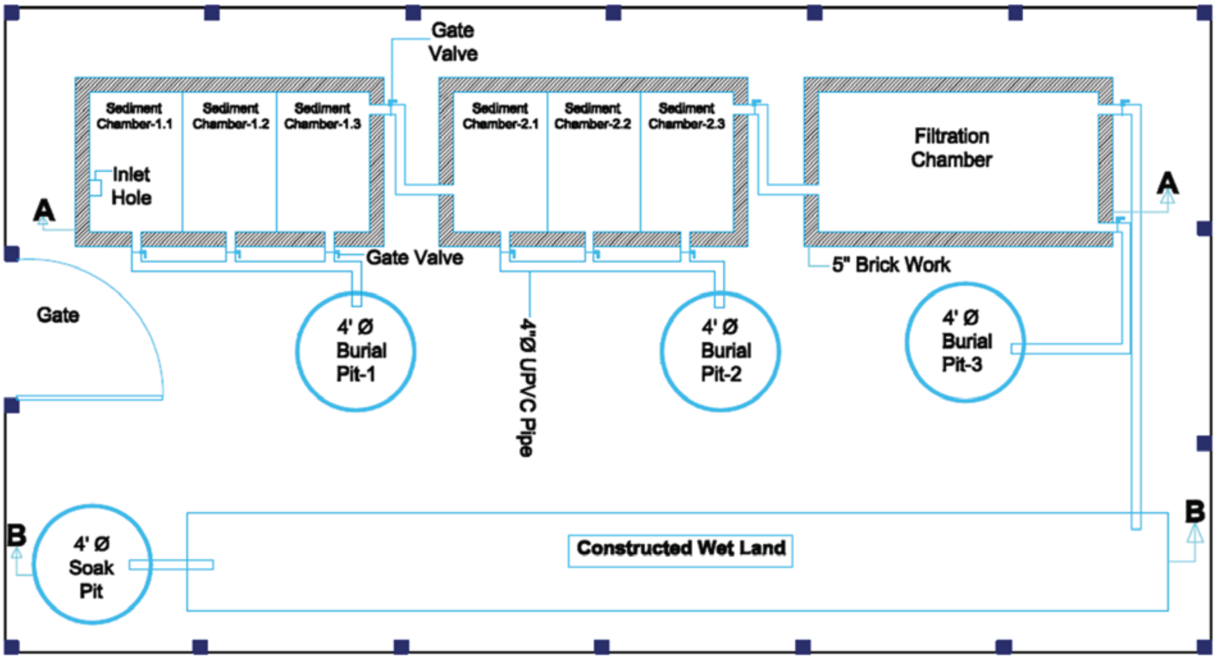

Figure 11: Plan view of the 4th generation system

This up-flow system helps settling of more solid particles. There is an outlet pipe at the top of the third compartment to allow the liquid from sedimentation chamber 1 to sedimentation chamber 2. The dimension of sedimentation chamber 2 is similar to the first chamber and also has three compartments. However, the liquid travels through all three compartments of the second chamber using up-flow system to facilitate further settling of solid in this chamber. After the second sedimentation chamber, the supernatant liquid of FS enters into the sedimentation-filtration chamber. Most of the solid gets trapped in the first two compartments.

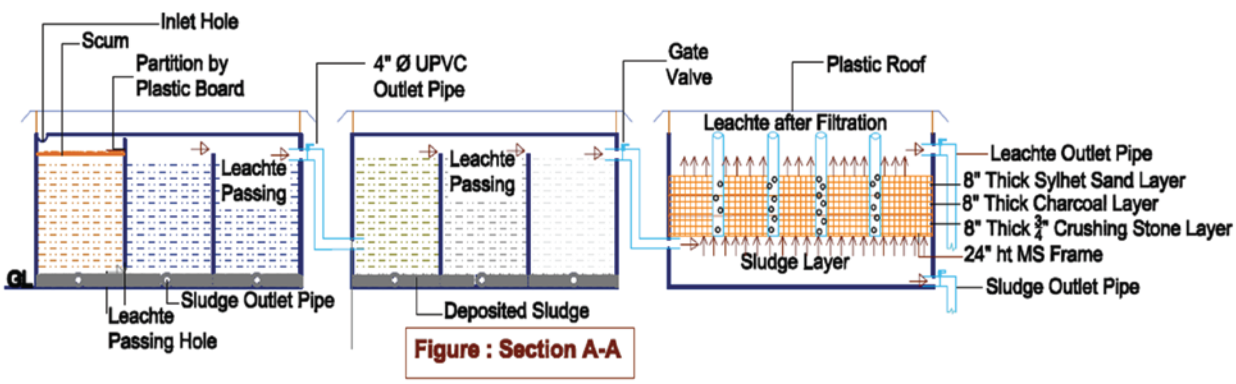

Figure 12: Cross-section of the three chambers of the solid-liquid separation unit of 4th generation system

The sedimentation-filtration chamber has same dimension as the sedimentation chambers (10' x 5' x 4.5'). In this chamber, there is a hollow section at the bottom having 20" in depth which is used as sludge layer, and there is a filter media placed on top of that hollow on an MS frame. The more clear FS coming out of second sedimentation chamber containing very little amount of solid enters at the bottom section (sludge layer) and rises up through the filter materials. The filter media is placed on an MS frame and has three layers:

- 8" layer of ¾" crushed stone
- 8" layer of charcoal
- 8" layer of Sylhet sand

The main purpose of the filter media is to remove the remaining solid particles from the liquid. Once the liquid reaches the top of the sedimentation-filtration chamber through up-flow, the liquid travels through the outlet pipe at the top towards the constructed wetland system for further treatment.

In the case of a possible clogging of the filter media, the filter media of the filtration chamber in the solid-liquid separation unit needs to be cleaned. In order to clean the media, at first, all three layers (sand layer, coal layer and stone layer) will be taken out of the chamber. Then Gravels can be washed by water and it will be dried and cleaned using sand papers. It is suggested that charcoal and sand are replaced. However, these materials can also be washed and reused if all the dirt can be removed from it properly.

2.4.2 3rd Generation FSTP

The main difference of a 3rd generation FSTP from 4th generation is that for 3rd generation plants, fecal sludge is first dumped into a dumping chamber at the FSTP having a capacity of 300 L(3.5' x 2.5' x 1'), instead of directly dumping into the solid-liquid separation unit.

Figure 13: Dumping chamber of 3rd Generation FSTP

From the flow diagram of 3rd generation FSTP shown in Figure 7, it can be seen that FS is directly pumped into dumping chamber after desludging from containment. If the plant distance from the containment is more than 150 m, FS is carried into an intermediate storage/dumping chamber, also called as secondary dumping chamber, which is a plastic tank of either 5,000 L or 2,000 L. There is a screener inside the dumping chamber which prevents unwanted materials like cloths, sanitary napkins, etc., from entering into the solid-liquid separation unit. This dumping chamber also acts as a temporary storage facility for the collected FS. From the dumping chamber, the sludge is transported into the sedimentation-filtration chamber through pipes by gravity flow.

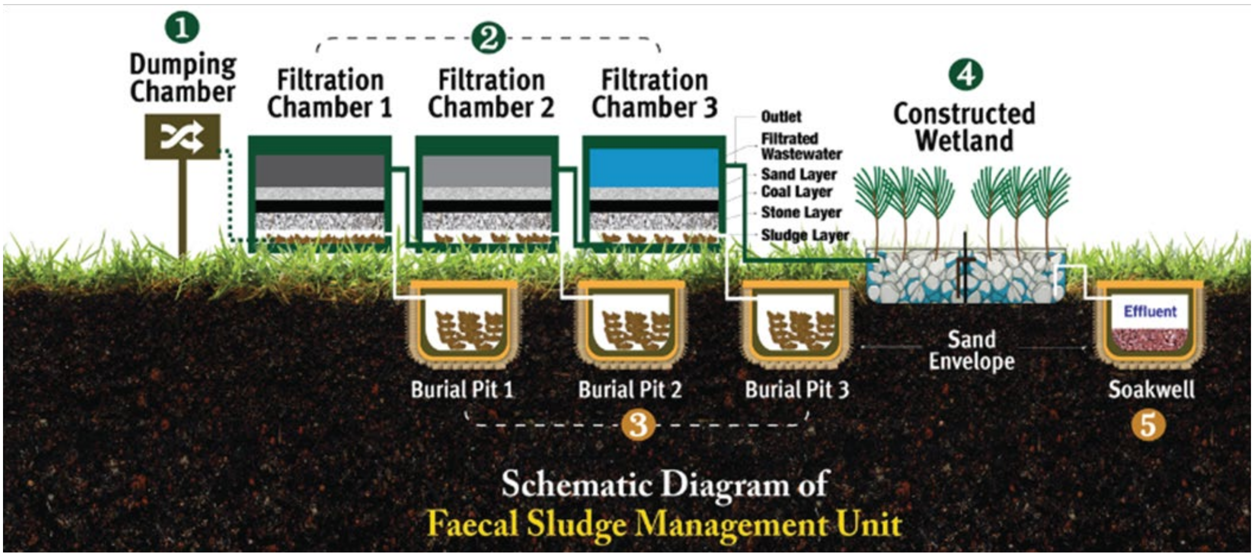

Figure 14: A schematic diagram of 3rd generation FSTP

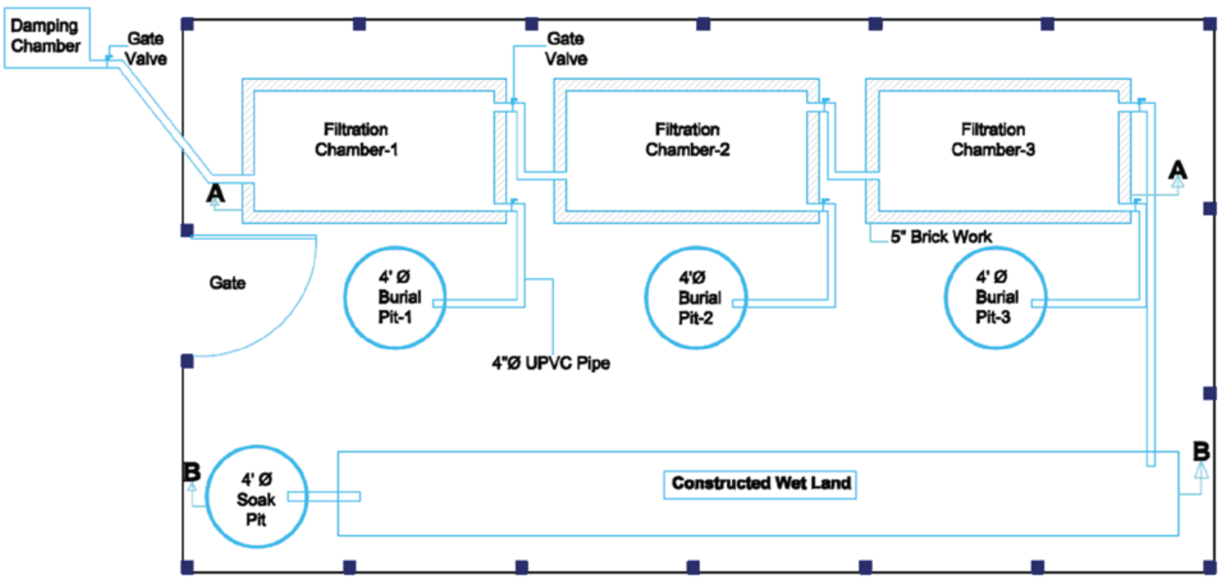

Figure 15: Plan view of the 3rd generation system

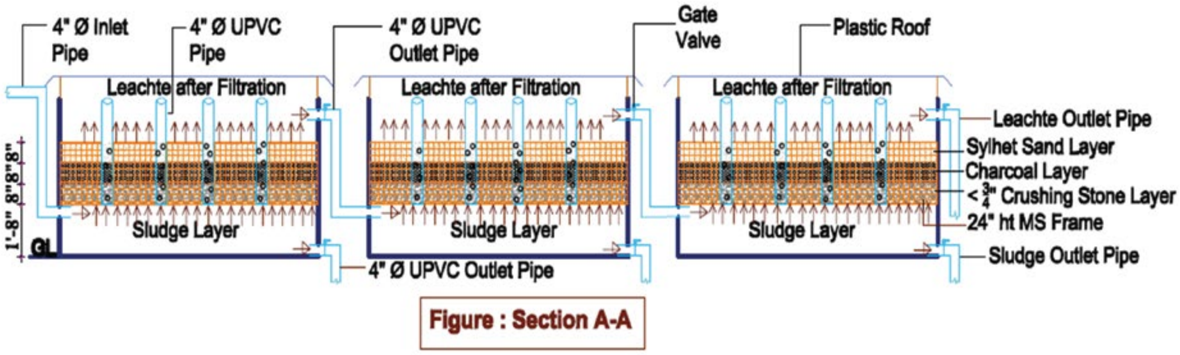

Figure 16: Cross-section of the three chambers of the solid-liquid separation unit of 3rd generation system

Solid-liquid separation unit of the 3rd generation treatment plants consists of three sedimentation-filtration chambers. Each chamber is similar to the third chamber of 4th generation system, which is also used as sedimentation-filtration chamber. All three chambers of the solid-liquid separation unit are connected to burial pits. The three chambers are connected in a way that the outlet pipe at the top of the first chamber is connected to the inlet pipe at the bottom of the second chamber. In the solid-liquid separation unit, the solid gets trapped at the bottom of the chamber while the liquid portion rises up through the filter by up-flow system. The separated solid parts are transported via an under drain pipe to the burial pits and stored there until the pits gets filled with sludge. The liquid part of the FS is transported into a constructed wetland after passing the third chamber, through gravity flow after coming out of the solid-liquid separation units. A schematic diagram of the 3rd generation system is shown in Figure 14.

Figure 15 shows the layout of the plant and connection between the three chambers of the solid-liquid separation unit. The dimensions of a chamber are 10' X 5' X 6'. Each chamber has a total volume of 5,000 L. In the filtration chamber, there is a hollow section at the bottom having 20" in depth which is used as sludge layer, and there is a filter media placed on top of that hollow on an MS frame. The filter media materials of 3rd generation filtration unit is similar to the filtration chamber of the 4th generation FSTP. The filter media is placed on an MS frame and has three layers:

- 8" layer of ¾" crushed stone
- 8" layer of charcoal
- 8" layer of Sylhet sand

Also, the cleaning process of the filter media if it ever gets clogged is same as the 4th generation FSTP.

To understand the efficiency of the 3rd and 4th generation systems as solid-liquid separation unit, research works need to be carried out for different loading conditions. However, it can be said that loading capacity of 3rd generation system is less than the 4th generation system, which makes the later a preferred option in the densely populated camp areas.

In general, the mechanism followed for solid-liquid separation in the system can be termed as settling-thickening process. The settling-thickening process is mostly used to achieve separation of the liquid and solid fractions of fecal sludge (FS). In the system, the settling-thickening tanks are rectangular tanks where FS is discharged into an inlet at the top of one side and the supernatant exits through an outlet situated at the opposite side, while settled solids are retained at the bottom of the tank, and scum floats on the surface.

While the main objective of settling-thickening is solid-liquid separation, it is not targeted for stabilization or pathogen reduction. Therefore, further treatment steps are required for both the thickened solids and supernatant. Considerations that should be taken while using such mechanism include:

- Dissolved organic matter, nutrients, and suspended particles will remain in the supernatant. Examples include 50% of influent COD in the settled sludge, and 50% in the supernatant (Badji et al., 2011).
- Total pathogen removal or inactivation is negligible in this system.
- Settled sludge may still have relatively high water content and requires further dewatering.

2.4.3 Burial pit

At the bottom of all three chambers of the solid-liquid separation unit, there is an underdrain system to direct the accumulated sludge into the burial pit. Each of the three chambers are connected to a burial pit that is 9' deep and 4' in diameter.

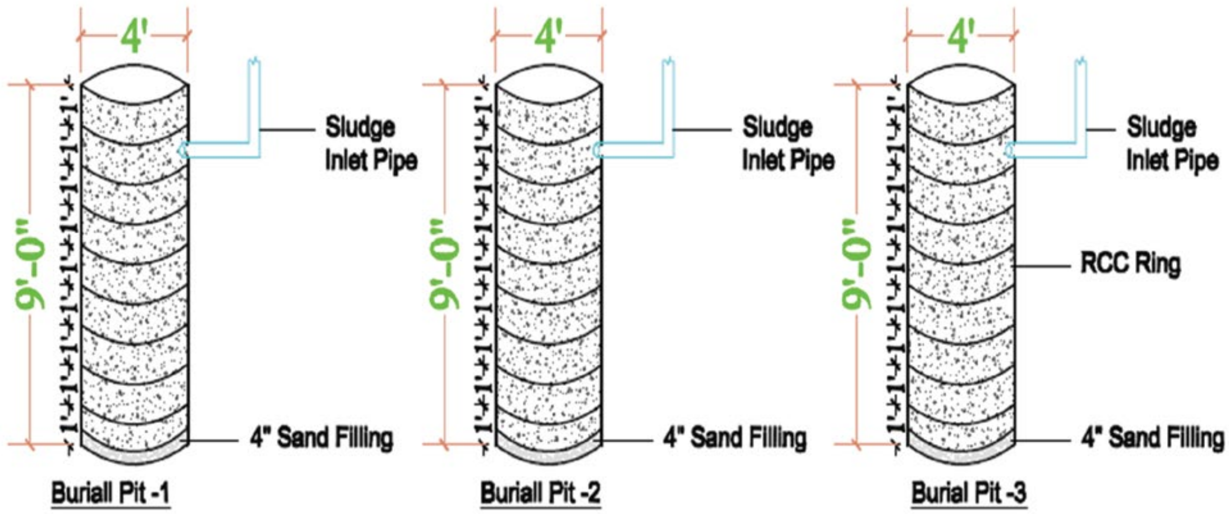

Figure 17: Burial pits for storage of separated solids from FS

Figure 18: Burial pits in the FSTP of Practical Action

There is a 4” sand filling at the bottom of the burial pit. Each of the pits has a minimum storage capacity of 1,500 liter. Each of the chamber also has a gate valve connected to the under drain pipe. This valve is used to control the flow of sludge into burial pits. After every 15-18 days (based on rate of solid deposition in the solid-liquid separation chambers), the outlets at the bottom of the three chambers of the solid-liquid separation unit is opened to let the accumulated solid part flow into the burial pits for storage where it also allows some natural degradation. The thickened sludge from the burial pits is disposed once the pits get filled up by sludge. This thickened sludge can be emptied using the hi-cap sucker. Sometimes the thickened sludge may harden and it can be hard for the nozzle vibration to liquefy this sludge. So, water can be added to make the sludge less hard, until the nozzle vibration is able to liquefy it easily. It is recommended that the solids, once removed from the burial pits, are treated in the drying beds and/or through any other methods for composting. Until such arrangements are made available at the camps, it is highly recommended that the sludge from the burial pits is disposed into a trench following health safety guidelines after digging a trench in the ground.

2.4.4 Constructed wetland with soak well

A constructed wetland is an engineered sequence of water bodies designed to filter and treat waterborne pollutants found in sewage, industrial effluent or storm water runoff. Constructed wetlands are used for wastewater treatment or for grey water treatment. Constructed wetlands are similar to filter beds, but are planted with emergent macrophysics, plants that are rooted in the bed but emerge above the sludge layer.

The plant requirements that need to be considered while designing a constructed wetland include:

- Fast growing under diverse conditions.
- High transpiration capacity.
- Tolerance to:

- Different water levels and drought condition
- Extremes of pH and salinity
- Deep growth rhizome and root system
- Ability to build new roots on the nodes when they become encased in sludge
- Readily available, indigenous and non-invasive

In Bangladesh, commonly used plants are: Cana Indica and Napier Grass. The major role of plants are biological uptake, drainage, filtration and O_2 transfer. The Nitrogen uptake could be 20 – 200 g N/m2.yr and Phosphorus uptake could be 3 – 15 g P/m2.yr. Depending on content of supernatant, this could be lower than these values. The roots and stems system also help maintain permeability.

Total bed depth of a constructed wetland is typically 60 – 90 cm. Plants are normally planted at a density between 4 to 12 plants/m2. Sufficient water must be available to keep plants alive. This suggests that constructed wetlands will be most suitable for lower strength FS with a high water content.

The constructed wetlands in the Rohingya camps' treatment plants are shallow trench with Canna Indica plants over stone bed to absorb pollutants naturally. The filter bed is 10' wide, 35' long and 3' deep. It has a minimum capacity of 6,000 liters. The bottom and sidewalls are sealed with RCC lining to ensure structural stability and to avoid contamination by seepage. A cross-section of the constructed wetland is shown in Figure 20.

Water loss from planted drying beds take place through a combination of evaporation, evapotranspiration from plants and percolation through the bed. Plant roots open up drainage paths in the sludge, facilitating both evaporation and percolation. The plants need to withstand varying watering regimes and nutrient loads.

Figure 19: Constructed wetland of the FSTP

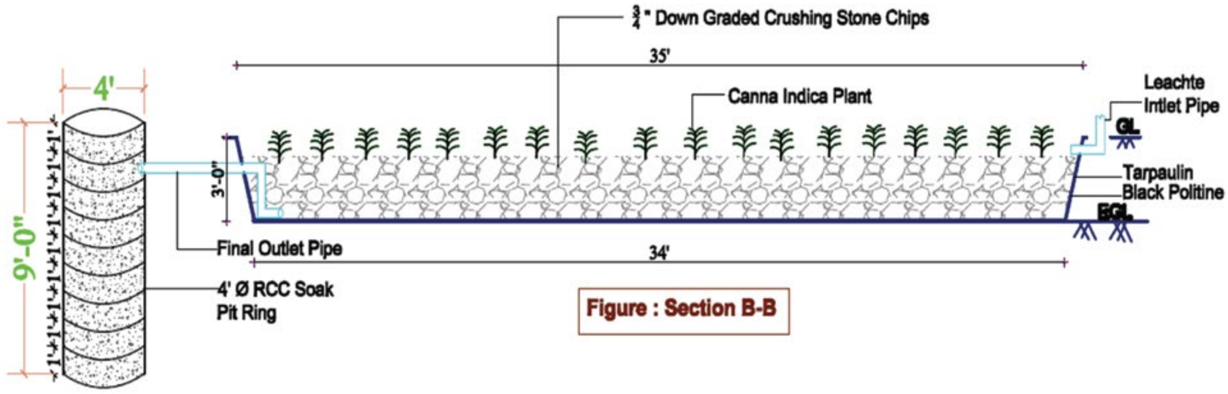

Figure 20: Cross section of Constructed Wetland with a soak well

Each constructed wetland is connected to a soak well which is 4ft. in diameter and 9ft. in depth. It is enveloped by 6 inch of sand and one third of it is filled by 40 mm graded brick chips. It has a capacity of minimum 3,000 liters. The liquid from the well infiltrates into soil which ensures further treatment of the liquid.

The major recommendations for the constructed wetland are:

- Vent pipes should be provided to allow air to reach the lower part of the bed.
- Continuous flow of liquid must be ensured to prevent drying up of plants. If there is not sufficient loading that might result in less inflow of liquid into the constructed wetland, the vertical flow system should be used instead of horizontal flow system.
- During heavy rainfall events, to prevent inundation and subsequent overflow of liquid mixed with rainwater which is rich in pathogen, a drainage system from the soak well should be connected to nearby wastewater drains.

2.4.5 Washing space

There is a washing space in the treatment plant that has been constructed for the workers to wash themselves after work. The space has been constructed with concrete with net cement finishing and has a dimension of 5 ft. x 4 ft. x 3ft. The washing space is provided with soap and water for hand washing and cleaning facilities to facilitate hygiene practices for the workers and the operators. The desludging equipment are also cleaned here.

Figure 21: Washing space for the sanitation workers

2.5 Sampling and Testing

Water quality sampling and testing allows to establish baseline values, ultimately increasing the knowledge and understanding surrounding the specific issues of a treatment plant. Major swings in parameter values can signify that something may be imbalanced leading to an unhealthy condition. Water testing results can provide in-the-moment values and aid in determining the best course of action. So, in order to check the treatment efficiency of the FSTPs in Rohingya camp, a number of samples were collected. These sampling were collected from both inlet and outlet locations of a plant. The samples were tested in the laboratory and summary of the results of the tests are presented here.

The samples were collected from the plants of camp 7, 15, 8E and 8W. A total of 34 samples were collected from the inlets and same number of samples were collected from the outlets of the same treatment plants.

From the test results, it can be seen that almost 91% (31 out of 34) of samples' pH values are within the ECR 97 standards (6.5-8.5). As for the outlets, only 29 of those 34 samples were found having pH value within that range. The results show a common trend for the pH values. In most cases, pH of the outlet samples are lower than the inlet samples. It's because those plants allow biological degradation. As a result, micro-organisms/bacteria generates $CO_2$by aerobic decomposition and CO_2in solution acts as an acid. Thus the pH level decreases for the outlet samples. As for the samples that were not found within the limits, application of controlled treatment condition in those plants can help reduce the risks.

According to the ECR97, 50 mg/L is the standard value of BOD for discharging it into inland surface water. As for discharging into public sewer and irrigated land, the standard value is 250 mg/L and 100 mg/L respectively. From all the test results, six inlet samples were found within the quality standard for discharging into public sewers. Among all the outlet samples, only nine of them were within acceptable limits of discharging into the sewer. Only one outlet sample has BOD value of 88mg/L. The rest of the inlet and outlet samples are way above the ECR standards. So all the samples need further treatments.

For COD, standard value for discharging in inland surface water, sewer and irrigated lands are 200 mg/L, 400 mg/L and 400 mg/L respectively. From the test results, it can be seen that COD decreases from inlet to outlet. The simple reason is the micro-organisms synthesizing the dissolved solids in the water. From the results, only five inlet samples were found within the acceptable limit for discharging into the public sewer or irrigated lands and eight outlet samples were within the limits for inland surface water discharge while two samples can be discharged into the public sewer or irrigated lands. The rest of the samples has a very high COD value and need advance treatments before discharging.

For Total Coli form and Fecal Coli form, all the samples exceeded the standard threshold and all the samples show the value TNTC (Too Numerous to Count).

Turbidity measures the clarity of the water. ECR97 doesn't have a set standard for turbidity. Almost all the inlet samples show a very high value of turbidity which varies from 150-25500 NTU. But almost all the outlet samples show low turbidity and 26% of them shows turbidity values less than 100 NTU. It indicated that the filtration system and the constructed wetland helps to significantly reduce the turbidity in water.

The Nitrate concentration of the samples ranges from 0.02 mg/L to 0.09 mg/L. The inlet samples show higher nitrate values than the outlet samples. The ECR97 standard value of Nitrate for unpolluted water is 0.1 mg/L. Hence, all the water samples are within the threshold limit. As for the changes in Nitrate concentration, there are some bacteria that synthesizes N_2 from the Nitrate. That's why the nitrate concentration decreases during the treatment process.

From the analysis, it can be clearly stated that most of the samples are highly polluted and undertreated. If these polluted water is discharged into the environment, it will endanger the ecosystem and its surroundings. Therefore, it is suggested that the treatment plants should be improved by adding advanced treatment technologies (e.g., planted filter bed). Until an advanced treatment system is used, the partially treated FS and supernatant liquid from the FSTPs should not be discharged into surface water or open environment where there is public health concern.

3. OPERATION AND MAINTENANCE TEAM

The latrine blocks and the containments in the camps are monitored and maintained by the responsible WASH agency for the block, who coordinate with the block focal organization. The block "Majhi" is responsible for reporting any issues related to repair and maintenance of the latrines and containments to the responsible WASH agency for the block. The WASH agency instructs the "volunteers", who are mainly from local communities, for carrying out any work related to repair and maintenance. The issues can also be discussed in WASH meetings. Apart from maintenance of the latrines and its containments, operation and maintenance at different steps of FSTP will be done by a team consisting trained members, termed as "sanitation workers" following the operation and maintenance guidelines.

Figure 22: Sanitation workers carrying the hi-cap sucker to the site of operation under the supervision of the volunteer.

Figure 23: Two sanitation workers operating the hi-cap sucker machine to collect FS from containment (left), one worker dumping FS into solid-liquid separation unit (middle), one worker looking after sludge collection pipe (right)

3.1 Organization of the Team

For operation and maintenance of the FSTPs, a team of 5 people is assigned for two FSTP units, who work under supervision of the responsible organization for operation and maintenance. Overall, the responsible personnel for operation and maintenance of the FSTPs are:

- Manager
- Field Coordinator
- Volunteer
- Sanitation Worker

The field coordinator will coordinate the operation, maintenance and management of all the FSTPs and will report to the Manager. The field coordinator will also communicate with the Majhi of the blocks. The FSTP management team structure is shown in Figure 24.

Each team of one volunteer and four sanitation workers is responsible for monitoring, operating and maintaining two FSTPs. The volunteer will supervise the sanitation workers at the FSTPs and report to the field coordinator. The specific responsibilities of each of the team members are provided below.

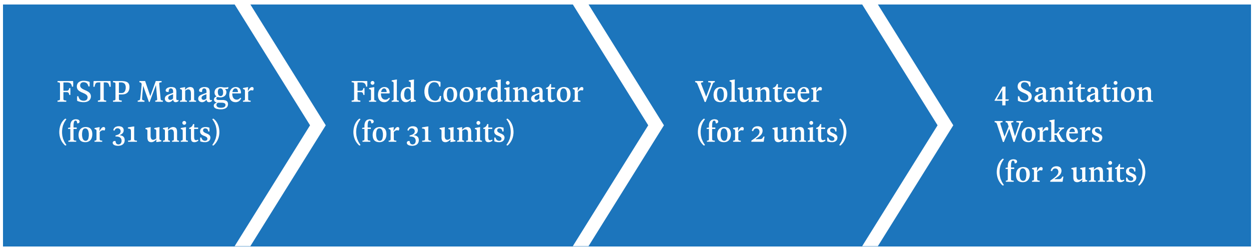

Figure 24: Team structure for O&M of two FSTPsResponsibilities

3.1.1 Manager

- Decision making regarding any issues related to plant management.
- Coordination with Camp-In-Charge (CIC), WASH block agency and focal organization of the blocks. Submission of reports to the CIC on plant performance.
- Attending all the relevant meetings and presenting the FSTP status in the meetings.
- Supervision of works of field coordinator and assigning tasks to the field coordinator.
- Organizing training and other supporting events for the O&M team.
- Checking the operation and maintenance records at regular interval.

3.1.2 Field Coordinator

- Assigning tasks to all the volunteers on daily basis.
- Preparing schedule for desludging of containments and disposal of FS at the FSTPs on daily basis for the volunteers.
- Monitors of the activities of the volunteers and sanitation workers on daily basis.
- Checking for complaints or issues raised by the volunteers and sharing them to the Manager.
- Assessing efficiency of the equipment and the plants at regular interval.
- Prepare reports on plant performance in consultation with Manager.
- Ensuring proper use of PPE by Volunteers and Sanitation Workers.
- Ensuring maintenance of the equipment and FSTP units following the schedule for maintenance.

3.1.3 Volunteer

- Collection of daily desludging schedule from the Field Coordinator.
- Providing instruction to the Sanitation Workers on their daily responsibilities as per the schedule.
- Monitoring of the FSM units and its daily operation by Sanitation Workers.
- Keeping activity records and providing daily report to Field Coordinator.
- Keeping close liason with Majhi regarding the use of latrine blocks and containment.
- Reporting any emergency situations, complaints and problems to the Field Coordinator.

3.1.4 Sanitation Workers

- Performing desludging of FS from the containment as per the desludging schedule.
- Operation of the FSTP units as per the operational guidelines.
- Reporting to the Volunteer after completion of each day's work.
- Reporting any relevant problems or issues to the Volunteer and Majhi.
- Maintenance of all equipment and safety gears.

In addition to the specific responsibilities mentioned above, all the team members should have good understanding of:

- Technical aspects of the FSTP, and its operation and maintenance procedures
- Desludging schedule, monitoring, reporting and other record keeping forms
- Occupational health and safety issues
- Communication procedure with different concerned staff and higher authority

4. OCCUPATIONAL HEALTH AND SAFETY

Sanitation workers provide an invaluable service that many of us notice only when confronted with blocked or filthy toilets; overflowing septic tanks. These workers are vital to the proper functioning of the sanitation systems that underpin daily life. The sanitation workforce, who are behind the provision and maintenance of sanitation systems, provides an essential public service. Beyond operational health and safety risks of working in direct contact with hazardous biological and chemical agents in dangerous environments, sanitation workers also face stigma and social discrimination resulting from the nature of their work.

The sanitation workers should typically be governed broadly under occupational health and safety (OHS) or occupational safety at work legislation. However, due to the specific nature of the work, guidelines articulating safeguarding sanitation workers are not widespread. Development partners and external agencies have a role to play in prioritizing this issue and supporting the reform agenda, which would likely need to cover three fundamental areas:

- Recognizing all types of sanitation work and provide the frameworks that enable the organization and empowerment of sanitation workers; workers' right to organize needs to be protected.
- Promotion of the gradual formalization and mechanization of the work while acknowledging the challenges of formalization.
- Articulating protection mechanisms, including legislation and standard operating procedures, covering measures such as personal protective equipment (PPE), training, regular health checks, insurance, and treatment for workers to mitigate their occupational risks across the sanitation chain.

The safety and health guidelines provided/needed for the workers in the refugee camps are discussed below.

4.1 Health & Safety Guidelines

The sanitation workers, especially the operators, are directly involved in the containment emptying and operation of FSTPs. As they are directly exposed to the FS stored in containments, they face a huge health risk on daily basis during their work. To reduce this risk and protect against illness, such as diarrhea, the following guidance should be followed by workers.

- Raise awareness about the public service and plight of sanitation workers and advocate for their health, safety, dignity, and rights.
- Implement policy, legislation and regulation to professionalize the workforce.
- Build the evidence base of who these workers are and the challenges they face in order to better define activities to support them.

- To develop compensation mechanisms for victims of FSM-related occupational illness or injury in line with national standards.
- To introduce insurance policies for emptiers to safeguard against workplace accident, injury.
- To organize training sessions on safe emptying and transportation.
- Provide protection gears and equipment for each worker involved in FSM.
- Presence of first aid kits for emergency accidents.

4.2 Protective Equipment

Workers handling FS should be provided with proper PPE, training on how to use it, and hand washing facilities. Workers should wash hands with soap and water immediately after removing PPE. The following PPE is recommended for workers handling human waste or sewage:

- Goggles: to protect eyes from splashes of fecal sludge.
- Protective face mask or splash-proof face shield: to protect nose and mouth from splashes of fecal sludge.
- Liquid-repellent coveralls: to keep sludge off clothing.
- Waterproof gloves: to prevent exposure to fecal sludge.
- Rubber boots
- Trousers

Figure 25: Splash-proof face shield

Figure 26: Goggles for Sanitation workers to protect eyes

Figure 27: Liquid repellant coveralls, Water proof gloves & Rubber boots

Other items should be provided used by the sanitation workers are-

- **Kerosene:** Can be used to decrease odors in septic tanks and pit latrines.
- **Bleaching Powder:** Use to disinfect gumboots, gloves, hoses and the area around the manhole.

Figure 28: Kerosene for odor control during desludging (left) and bleaching powder to disinfect equipment (right)

Figure 29: A sanitation worker performing his operation wearing Safety gears.

5. STEPS FOR FSTP OPERATION

The sanitation workers involved in day to day operation of FSM in Rohingya camp faces the difficult task of emptying the containments and disposing collected FS into the FSTP while facing huge health safety risk. In order to help them clearly understand their daily responsibilities, it is important to demonstrate the tasks that each worker and volunteer need to carry out. Therefore, the Manager and Field Coordinator should prepare a schedule of desludging for the volunteers and sanitation workers. The schedule for desludging operations should be prepared at least one day prior to operation and will be shared with volunteers. The volunteers will then inform the sanitation workers so that they can take adequate preparation for carrying out the operation.

A step-wise operational procedure for each step of operation has been prepared based on the working principle of the FSTPs. Table 2 presents the actions of the volunteers and sanitation workers related to the daily operation at FSTPs.

Table 2: Step-wise operational procedure at the FSTP

Step	Activity	Sub-activity	Responsible staff
(A) Hi-cap sucker operati on	(a) Routine check up	(1) Collect the hi-cap sucker and its accessories from the store room. Clean the machine with a brush or soft cloth before use.	SW[3] 1-4
		(2) Check if there is any damage in the hi-cap sucker and/or leakage/damage/cracks in the sludge conveyance pipe, modified nozzle pipe and the joints.	SW 1-4
		(3) Check the diesel/lubricant level in the diesel engine. If needed, fill up the chambers with diesel/lubricant.	SW 1-4
	(b) Setting up the machine	(4) Carry the hi-cap sucker, diesel engine and pipes to the site (containment)where desludging will be done (according to the desludging schedule).	SW 1-4
		(5) Keep the engine in a suitable location. The place should be clean and level, and no mud should be around and the machine should be placed on the ground horizontally.	SW 1

[3] SW = Sanitation Worker

Step	Activity	Sub-activity	Responsible staff
(A) Hi-cap sucker operation	(b) Setting up the machine	(6) Connect the pipes (modified nozzle pipe and suction pipe) properly with the outputs of the diesel engine.	SW 1
		(7) Remove the manhole or lid of the pit/septic tank.	SW 2
		(8) Insert pump into the containment below the water level almost perpendicular to ground. Make sure that the suction pipe inlet is below the wastewater level in the containment. Also make sure that the nozzle head is properly sunk into faecal waste.	SW 2
	(c) Setting up the pipes	(9) Carry the conveyance pipe from the containment to the dumping/intermediate storage chamber or solid-liquid separation chamber.	SW 3-4
		(10) Insert the outlet of the conveyance pipe into the inlet hole of dumping/intermediate storage or solid-liquid separation chamber.	SW 4
	(d) Start desludging	(11) Once step 10 is done by SW 4, he/she will send signal to SW 1 for starting the engine of the hi-cap sucker. (12) Start the hi-cap sucker engine to start desludging of FS from containment. (13) Ensure that the outlet pipe inside the dumping chamber is in right position and monitor if FS is dumped properly in the chamber.	SW 2 SW 1 SW 3

Step	Activity	Sub-activity	Responsible staff
(A) Hi-cap sucker operation	(d) Start desludging	(14) Once the desludging starts, monitor the conveyance pipe during the operation to keep the pipe steady.One sanitation worker will constantly monitor the FS collection pipe. If FS flows through the pipe, operation should continue. But if there is no flow, any of the two cases might be the reason: • Case 1: Containment emptying is done and there is no FS inside the containment to desludge. • Case 2: The screen of the pump (see figure below) got clogged or the fan inside the screen has stopped rotating due to clothes or other materials getting stuck in the fan. In case of no flow through the pipe, the engine must be shut down immediately. Otherwise, the nozzle might get damaged. For case 1, the workers should stop operation. For case 2, the screen must be cleaned before starting the engine again.	SW 4
	(e) End operation	(15) Once the containment is nearly empty, SW 2 will send signal to the generator operator (SW 1).	SW 2
		(16) Shut down the generator.	SW 1
		(17) Send signal to SW 3 and SW 4 for the end of operation for this site.	SW 1
		(18) Remove the hi-cap sucker from the containment.	SW 2
		(19) Close the lid of manhole.	SW 2
		(20) Detach the pipes from the machine.	SW 1 – 4

Step	Activity	Sub-activity	Responsible staff
(A) Hi-cap sucker operation	(e) End operation	(21) Wash the hi-cap sucker machine at the washing space with water to clean sludge from it.	SW 2
		(22) Ensure that all the equipment are cleaned and packed properly. Then move to next site or to the office (if operation for the day is closed).	SW 1 – 4
	(f) Keeping Record	(23) Enter the date of desludging of the containment into the logbook.	Volunteer
(B) Dumping/ intermedia tedumping chamber	(a) Inspection	(24)Open the lid of the dumping/intermediate dumping chamber and check if there is space available for further dumping of FS into the chamber.	SW 4
		(25) Check for any clogging in the outlet pipe of the dumping chamber (for 3rd generation system)that is connected to the solid-liquid separation chamberand clean if necessary.	SW 4
	(b) Dumping into the chamber	(26)Insert the outlet pipe of the hi-cap sucker into the chamber through the inlet hole. Ensure the pipe is inside to avoid any splashing or spewing during emptying of containment.	SW 4
		(27)After emptying is done (when signaled by SW 1), eject the pipe from the chamber.	SW 4
		(28) Close the lid of the chamber after dumping of FS is done.	SW 4
		(29) Clean the surrounding area of the chamber to remove any FS spewed around the chamber.	SW 4

Step	Activity	Sub-activity	Responsible staff
(C) Solid-liquid separation chamber	(a) Inspection	(30) Open the lid of the chamber and check if there is space available for further dumping of FS into the chamber.	SW 4
	(b) Dumping into the chamber	(31) Insert the outlet pipe of the hi-cap sucker at the bottom section into the first of the three chambers. Ensure the pipe is placed properly inside of the chamber to avoid any splashing or spewing.	SW 4
		(32) After end of desludging operation as signaled by SW 1, eject the pipe from the chamber.	SW 4
		(33) Close the lid of the chamber after dumping of FS is done.	SW 4
		(34) Clean the surrounding area of the chamber to remove any FS spewed around the chamber.	SW 4
	(c) Check flow condition	(35) During operation, check if there is up-flow of faecal waste.If there is no flow coming out of the sedimentation-filtration chambers, then the filter media is clogged and needs to be cleaned before further use.	SW 4
		(36) Check if the gate valves for controlling flow of faecal waste through the pipes between the chambers are open. If there is no flow despite the gate valves being open, check if the inlet pipe is clogged. If so, clean the pipe before any further loading of FS into the solid-liquid separation chambers.	SW 4
		(37) Check if there is any overflow over the side walls of the chambers. If any, tell SW 1 to stop the engine. Check step 36.	SW 4

Step	Activity	Sub-activity	Responsible staff
(D) Constructed wetland	(a) Routine inspection	(38) Check if the inlet pipe that connects the solid-liquid separation unit with the constructed wetland is not closed or clogged, and supernatant liquid is flowing into the constructed wetland. If son, then clean the pipe and make sure that the gate valve that controls the flow of supernatant from solid-liquid separation chamber to constructed wetland is open.	SW 4
		(39) If there is any overflow of supernatant liquid over the constructed wetland, stop dumping of FS in the dumping chamber and check for any clogging in the media. If the filter media is found to be clogged and not allowing filtration of liquid, clean the filter media before further use.	SW 4
		(40) Check if there is any mud or waste on the surface of the filter media. If yes, clean the surface of the media.	SW 4
(E) Soak well	(a) Routine inspection	(41) Open the lid of the soak well and check the level of water inside the well.	SW 4
		(42) If there is any overflow of liquid, empty the liquid of the soak well using the hi-cap sucker and ensure that the liquid is drained out to the nearby wastewater drains.	SW 1-4
(F) Burial pit	(a) Routine inspection	(43) Open the lid of the pit and check the level of thickened sludge inside the pit	SW 4
		(44) If the pit is about to get filled up, empty the sludge and dispose into soil by digging a trench following health safety guidelines.	SW 1-4
	(b) Operation	(45) Open the gate valve of the burial pit to let the accumulated sludge from the sedimentation chamber (only for 4th generation system) or sedimentation-filtration chamber flow into the burial pit.	SW 4
		(46) Close the gate valve of the burial pit and the lid/cover.	SW 4

6. MAINTENANCE STEPS

The maintenance works are not always about repairing, rather itis intended to follow up with the regular and methodological processes to keep the equipment up to date and in working condition. The main purpose of regular maintenance is to ensure that all equipment required for operations are operating at desired efficiency at all times. Through short daily inspections, cleaning, lubricating, and making minor adjustments, small problems can be detected and corrected before they become a major problem that can shut down the system at times. If a small problem is not possible to be solved immediately, it should be planned as soon as possible to avoid system failure. A good maintenance program requires organization-wide participation and support by everyone ranging from the top executive to the plant workers. The following table describes the type of maintenance required for FSM units, frequency of maintenance works and the responsible person for the maintenance.

Table 3: Maintenance work plan for the FSTP

Step	Maintenance Work	Frequency of maintenance work	Responsible staff
Hi-cap sucker unit	Properly clean the components of the hi-cap sucker including the nozzle pipe, sludge collection pipe, screen chamber and other parts at the end of the day's work.	Every day after close of work.	SW 1 – 4
	Check the level of lubricants and oil in their respective storage chambers in the hi-cap sucker and fill the chambers if needed.	Every day before start of work.	SW 1 – 4
	Apply grease on the parts of the hi-cap sucker machine to keep it efficient and protect the machine from rust.	Every week.	SW 1 – 4
Dumping/ intermediat estorage chamber	Clean the outside walls of the dumping chamber with brush and water to preventalgal growth or vegetation.	Every month.	SW 1 – 4
	Clean inside of the chamber to make sure that hardened solids do not reduce the effective volume of the chamber.	Every month.	SW 1 – 4
	Check the outlet of the chamber and remove any clogging particles/solid.	Every week.	SW 1 – 4
	Keep the platform and surrounding area of the chamber clean and hygienic.	Every week.	SW 1 – 4

Step	Maintenance Work	Frequency of maintenance work	Responsible staff
Dumping/ intermediat estorage chamber	Repair any damage or broken part of the chamber.	As soon as any damage or broken part is noticed.	Volunteer will inform Field Coordinator and Manager.
Solid-liquid separation chamber	Clean the outside walls of the sedimentation chamber and filtration chamber of the solid-liquid separation units with brush and water to prevent algal growth or vegetation.	Every month.	SW 1 – 4
	Routinely mow/remove undesirable vegetation from filter beds. Treat noxious weeds and other unwanted vegetation as not needed throughout the filtration bed. This activity can be performed either through mechanical means (mowing/pulling) or with herbicide. Consultation with a local Weed Inspector is highly recommended prior to the use of herbicide. Herbicides should be utilized sparingly and only as a last resort.	Every month.	SW 1 – 4
	Routinely check for debris/sediment accumulation and possible blockage of the filter media and clean the filter materials, if necessary.	Every three month.	SW 1 – 4
	To clean the filter media, all three layers (sand layer, coal layer and stone layer) will be taken out of the chamber. Gravels can be washed by water easily. Then it will be dried and cleaned using sand papers.It is suggested that charcoal and sand should be replaced. However, these materials can also be washed and reused if all the dirt can be removed from it properly.	Every three month.	SW 1 – 4
	Check the underdrain pipe and clean anyclogging of the underdrain pipe.	Every week.	SW 1 – 4
	Repair the eroded areas to ensure the proper functioning of the filtration chamber, to minimize sediment transport, and to reduce potential impacts to other features.	As soon as any damage or broken part is noticed.	Volunteer will inform the Field Coordinator.

Step	Maintenance Work	Frequency of maintenance work	Responsible staff
Constructed wetland	Properly maintain the ground cover of wetlandto prevent erosion of the embankment. This can be done by removing any object (other than plant units) within 4-5 ft. of the wetland basin.	Every month.	SW 1-4
	Check vegetation conditions in the wetland area.Ensure that the plants roots are not dry. If needed, water the plants is dry season. If any dead plant is found, replace with new plant.	Every week.	Volunteer will inform Field Coordinator.
	Mow invasive plant/vegetation from the wetland basin.	If plant/vegetation are invasive.	SW 1-4
	If burrows are detected within the constructed wetland area, the rodents should be dealt with by removal.	Whenever the problem is detected.	SW 1-4
	Check for trash within the wetland.Keep the constructed wetland area clear of debris such as loose bottles, cans, food containers and other forms of rubbish.	Every week.	SW 1-4
	Inspect the conduits thoroughly and clean any clogging or debris accumulation.	Every three month.	SW 1-4
	Inspect the pipes for proper alignment (sagging), elongation and displacement at joints, cracks, leaks, surface wear, loss of protective coating, corrosion and blocking.	Every three month.	Volunteer will inform the Field Coordinator.
Burial Pit	Clean the outside wall of the chamber with brush and water to protect from algal growth or vegetation.	Every month.	SW 1 – 4
	Repair any damage or broken part of the pit.	As soon as any damage or broken part is noticed.	Volunteer will inform Field Coordinator and Manager.

Step	Maintenance Work	Frequency of maintenance work	Responsible staff
Washing space	Clean the outside wall and inside of the washing space with brush and water to protect from algal growth or vegetation.	Every month.	SW 1 – 4
	Repair any damage or broken part of the space.	As soon as any damage or broken part is noticed.	Volunteer will inform Field Coordinator and Manager.
Safety gears	Clean the washable gears such as-gloves, rubber boots etc. with bleaching powder after each days of work.	Everyday.	SW 1-4
	Wash and dry the body coveralls.	Everyday.	SW 1-4
	Inform the authority for replacement of safety gears when damaged.	As soon as any damage is noticed.	Volunteer will inform Field Coordinator and Manager.

7. EMERGENCY PREPAREDNESS

Operational activitiesat the FSTP should accommodate planning for any expected emergency scenario. Successful emergency operation of the FSTP depends on plant operators knowing the optional flow characteristics designed into the plant facility, and also knowing, through normal operation and maintenance, all the control valves and emergency equipment are working properly and ready for immediate use.

In the case of any accidents or a medical emergency, there should be a fast-acting medical team available near the facility. Emergency fire drills or mock drills for situation concerning other hazard such as land slide, cyclone drills should be performed and included in the safety policy.

The schedule for desludging is often not fixed or properly organized in the Rohingya camp. Although there is a tentative date for desludging, sometimes there comes an emergency situation where a containment gets filled up earlier than expected and it starts to overflow. In such cases, team needs to coordinate to act quickly to desludge the containment on emergency basis. To avoid this from happening, the record of desludging should be checked regularly to identify containments with the requirement of higher frequency of desludging.

Overflow from burial pit/soak well is another type of emergency that needs special attention as the overflowing waste is detrimental to the surrounding environment. In these cases, the burial pit/soak well should be desludged as soon as possible. An overflow condition needs immediate attention, which is the reason the emergency storage facility, the bypass piping, and redundant pumps should be provided. Additionally, a separate power engine should be provided in the case of the working engine stopped working.

The FSTP sludge units often produce methane gas. So, the case of fire is quite possible. That's why sufficient fire extinguishers should be available at the FSTP and the sanitation workers and volunteers should be trained in fire safety drills.

8. SUPPORTING PROGRAM

Training the sanitation workers/volunteer/manager/field coordinator is important that is required for ensuring efficiency in works of FSM. A well-trained employee will be well acquainted with the job and will need less supervision. Thus, there will be less wastage of time and efforts. Errors are likely to occur if the workers lack knowledge and skills required for doing their particular job. The more trained an employee is, the less are the chances of committing accidents in their work and the more proficient they become.

FSTP operators must be qualified utility operators familiar with the equipment and processes of the FSTP. They must have the ability to operate FSTP equipment, collect, compile, and evaluate operating information, and to plan necessary actions and maintenance procedures to ensure continued proper operation of the plant. Each staff, from Manager to Sanitation Worker, must be trained in management and emergency responses. Also, they should be knowledgeable about the technical functions of the FSTP units. The utility operators should be able to use sound judgment to take quick decision on when and where to obtain additional support. FSTP system operators are required to have the following training:

- Utility functionality
- Electrical safety
- Pollution control
- Occupational health and safety with training on basic hygiene practice, use and disposal of personal protective equipment; and proper handling of fecal sludge.
- Use of first aid kit
- Emergency drills

Training on above subjects should be conducted for Managers, Field Coordinator, Volunteers, Sanitation Workers and Majhi of the camps. The trainings should repeat at least once a year. Any newly recruited staff should receive all the training prior to starting work at the plant.

9. REVIEW AND UPDATE O&M MANUAL

An operation and maintenance manual is needed to be updated over time. With the progress of time, it is expected that the system will be upgraded. These upgrades can be the addition of new technology or adding new facility to the system. So, the operation and maintenance of those new technology will need to be addressed in the manuals. Therefore, this manual may have to be revised once any change in the FSTP is made. Moreover, based on feedback from the workers, the manual could be updated to make it more user-friendly. Hence, it is suggested to review the manual after any modification in the plant (design and operation) or at least once in every year.

Appendix A-1:

GLOSSARY

Term	Definition
Clogging	To obstruct or become obstructed with thick or sticky matter.
Containment	The action of keeping something harmful under control or within limits.
Constructed Wetland	An artificial wetland to treat municipal or industrial wastewater, greywater or stormwater runoff.
Degradation	The act or process of damaging or ruining something.
Faecal Waste/Sludge	Mixture of human excreta, water and solid wastes (e.g. toilet paper or other anal cleansing materials, menstrual hygiene materials) that are disposed of in pits, tanks or vaults.
Filtration	The process in which solid particles in a liquid or gaseous fluid are removed by the use of a filter medium that permits the fluid to pass through but retains the solid particles.
Hazards	Any agent that can cause harm or damage to humans, property, or the environment.
Hygiene	Conditions or practices conducive to maintaining health and preventing disease, especially through cleanliness.
Noxious	Things that are harmful or injurious to health or physical well-being.
Protocols	A system of rules that explain the correct conduct and procedures to be followed in formal situations.
Runoff	Quantity of water discharged in surface streams.
Sedimentation	The action or process of forming or depositing sediment.
Seepage	The slow escape of a liquid or gas through porous material or small holes.
Stakeholders	Stakeholders in a typical corporation are its investors, employees, customers and suppliers.
Vegetation	Plants considered collectively, especially those found in a particular area or habitat.
Utility	A term in economics that refers to the total satisfaction received from consuming a good or service.

Appendix A-2:

DESLUDGING SCHEDULE

Latrine/ Containment ID	Disposal FSTP ID	Camp No.	Block No.	Sub-block No.	Name of Majhi	Contact No. of Majhi	Name of Volunteer	Contact No. of Volunteer	Containment Type (Pit/ Septic Tank)	Frequency of emptying (e.g., twice per month)	Last Emptying Date	Next Emptying Date	Emptying History (Date)

Appendix A-3:

DAILY EMPTYING LOG SHEET

Emptying Date: July 31, 2020

Working group (Name or number of group with one volunteer and four workers)	FSTP ID (where FS will be disposed next day)	ID of Latrine/ Containment to be emptied next day							
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

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UPFLOW FILTRATION FSM SYSTEM IN ROHINGYA CAMPS

Operations & Maintenance (O&M) Manual

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